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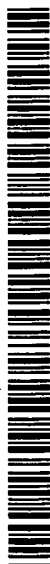
(54) Title: ADAPTIVE EARLY EXIT TECHNIQUES FOR MINIMUN DISTORTION CALCULATION IN IMAGE CORRELATION

(57) Abstract: An image processor that calculates values that are related to distortion between two image parts. The values are detected in a previous calculation. Those values are then used in the next calculation cycle to detect an early exit. That value, called least, divided by the number of accumulators, and its negative is loaded into the accumulators. When the accumulators reach zero, an early exit is established.

ADAPTIVE EARLY EXIT TECHNIQUES FOR MINIMUM DISTORTION CALCULATION IN IMAGE
CORRELATION

BACKGROUND

5   Image compression techniques can reduce the amount

of data to be transmitted in video applications. This is

often done by determining parts of the image that have

stayed the same. The "motion estimation" technique is

10   used in various video coding methods.

Motion estimation is an attempt to find the best

match between a source block belonging to some frame N

and a search area. The search area can be in the same

frame N, or can be in a search area in a temporally

15   displaced frame N-k.

These techniques may be computationally intensive.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects will now be described in

20   detail with reference to the accompanying drawings,

wherein:

Figure 1 shows a source block and search block being

compared against one another;

Figure 2 shows a basic accumulation unit for

25   measuring distortion;

Figure 3a and 3b shows different partitioning of the

calculations among multiple SAD units;

Figure 4 shows a tradeoff between early exit

strategy calculations and an actual total calculation;

Figure 5 shows a flowchart of the early exit

5   strategy;

Figure 6a shows an early exit using an early exit

flag;

Figure 6b shows early exit using a hardware status

register;

10   Figure 7 shows a flowchart of operation of the

adaptive early exit strategy.

15   DETAILED DESCRIPTION

Motion estimation is often carried out by

calculating a sum of absolute differences or "SAD".

Motion estimation can be used in many different

applications, including, but not limited to cellular

20   telephones that use video, video cameras, video

accelerators, and other such devices.   These devices can

produce video signals as outputs.   The SAD is a

calculation often used to identify the lowest distortion

between a source block and a number of blocks in a search

region search block. Hence the best match between these

blocks. One way of expressing this is

$$SAD = \sum_{i=0}^{N-1}\sum_{j=0}^{n-1} |a(i,j)-b(i,j)|, \quad N =2,4,8,16,32,64.$$

. Conceptually what this means is that a first frame

5   or source block (N) is divided into component parts of

MxN source blocks 100. These are compared to a second

frame (N-K) 102. The frames can be temporally displaced,

in which case k≠0. Each N-K frame 102 is an $M+2m_1$ x $N+2n_1$

area. The source block 100 is shown in the center of the

10   area in Fig. 1. The parts of the images that match can

be detected by correlating each part of each image frame

against other image frame using the distortion measurer.

The compression scheme uses this detection to compress

the data, and hence send less information about the

15   image.

This device can also be part of a general-purpose

DSP. Such a device is contemplated for use in video

camcorders, teleconferencing, PC video cards, and HDTV.

In addition, the general-purpose DSP is also contemplated

20   for use in connection with other technologies utilizing

digital signal processing such as voice processing used

in mobile telephony, speech recognition, and other

applications.

The speed of the overall distortion detection
process can be increased. One way is by using hardware
that allows each SAD device to carry out more operations
in a cycle. This, however, can require more expensive

5   hardware.

Another way is to increase the effective pixel
throughput by adding additional SAD devices. This can
also increase cost, however, since it requires more SAD
devices.

10   Faster search algorithms attempt to use the existing
hardware more effectively.

The block SAD compares the source group against the
"search group". The source group and the search group
move throughout the entire image so that the SAD

15   operation calculates the overlap between the two groups.
Each block in the source group will be compared to
multiple blocks in each of the search regions.

A typical SAD unit operates on two, 16 by 16
elements to overlay those elements on one another. This

20   overlay process calculates 16 X 16 = 256 differences.
These are then accumulated to represent the total
distortion.

The SAD requires certain fundamental operations. A
difference between the source X_{ij} and the search Y_{ij} must

be formed. An absolute value $|X_{ij}-Y_{ij}|$ is formed.

Finally, the values are accumulated, $SAD = \sum_{i=0}^{N-1}\sum_{j=0}^{n-1} |X_{ij}-Y_{ij}|$.

A basic accumulation structure is shown in Fig. 2

Arithmetic logic unit 200 receives X_{ij} and Y_{ij} from data

5   buses 198,199 connected thereto, and calculates $X_{ij}-Y_{ij}$.

The output 201 is inverted by inverter 202. Both the

inverted output, and the original, are sent to

multiplexer 204 which selects one of the values based on

a sign bit 205. A second arithmetic logic unit 206

10 combines these to form the absolute value. The final

values are stored in accumulation register 208.

Effectively, this forms a system of subtract, absolute,

accumulate, as shown in Figure 2.

Figure 2 shows a single SAD computation unit. As

15 noted above, multiple computation units could be used to

increases the throughput. If the number of computation

units is increased, that increases, in theory, the pixel

throughput per cycle.

The present inventor noted, however, that increase

20 in pixel throughput is not necessarily linearly related

to the number of units. In fact, each frame is somewhat

correlated with its neighboring frames. In addition,

different parts of any image are often correlated with

other parts of the image. The efficiency of the

compression may be based on characteristics of the
images. The present application allows using the
multiple SAD devices in different modes, depending on the
efficiency of compression.

5   The present application uses the architecture shown
in Figures 3A and 3B. The same connection is used in
both Figures 3A and 3B, but the calculations are
partitioned in different ways.

Figure 3A shows each SAD device 300, 302 being
10   configured as a whole SAD. Each SAD receives a different
block, providing N block SAD calculations. Effectively,
unit 301, therefore, calculates the relationship between
a 16 by 16 reference and a 16 by 16 source, pixel by
pixel. Unit 2, 302 calculates the result the difference
15   16 by 16 source and the 16 by 16 search pixel by pixel.
The alternative shown in Figure 3B. In this alternative,
configuration each single SAD 300, 302 performs a
fraction of a single block SAD calculation. Each of the
N computation units provides 1/N of the output. This
20   "partial SAD" operation means that each of the 8 bit
subtract absolute accumulate units have calculated 1/N of
the full SAD calculation configured to that unit.

The overall system that determines the whole or
partial should be used based on previous results as

described herein. This in turn can reduce the number of

calculations that is carried out.

One way to determine whether whole or partial is

used is to assume that temporally close images have

5   correlated properties. A first cycle can be calculated

using the whole SAD mode, and a second cycle can be

calculated using the partial SAD mode. The cycle which

works faster is taken as the winner, and sets the SAD

mode. This calculation can be repeated every X cycles,

10   where X is the number of cycles after which local

temporal correlation can no longer be assumed. This can

be done in a logic unit, which carries out the flowchart

of Figure 7, described herein.

Throughput can also be increased by an "early exit"

15   technique as described herein.

The complete SAD calculation for 16x16 elements can

be written as $|p_1r - p_1s| + |p_2r - p_2s| + ... |p_{256}s - p_{256}r|...(1)$. If all of these calculations were actually

carried out, the calculation could take 256/N cycles,

20   where N is the number of SAD units. It is desirable to

stop the calculation as soon as possible. Interim results

of the calculation are tested. These interim results are

used to determine if enough information has been

determined to find a minimum distortion. The act of

testing, however, can consume cycles.

The present application describes a balance between

this consumption of cycles and the determination of the

5   minimum distortion. Figure 4 illustrates the tradeoff

for a 16x16 calculation using 4 SAD devices. Line 400 in

Figure 4 represents the cycle count when there is no

early exit. The line is horizontal representing that the

cycle count without early exit is always 256/4=64.

10   The cycle counts for early exit strategies are shown in

the sloped lines 402, 404, 406 and 408. Line 404

represents one test every sixteen pixels, line 406

represents one test every thirty-two pixels (1/8) and

line 408 represents one test every sixty-four pixels

15   (1/16). Note that when the lines 402-408 are above line

400, the attempt at early exit has actually increased the

overall distortion calculation time. Line 402 represents

the cycle consumption where zero overhead is obtained for

exit testing. That is, when a test is made, the exit is

20   always successful. Line 402 is the desired goal. An

adaptive early exit scheme is disclosed for doing so.

Block I is first processed using any normal strategy

known in the art to find a minimum distortion. This can

be done using test patterns, which can be part of the

actual image, to find the distortion. This minimum

distortion is used as the baseline; and it is assumed

that block I + n, where n is small, has that same minimum

distortion. Two basic parameters are used.

5   Kexit(N) represents the number of pixels that have

been processed previously for a search region before an

early exit is achieved.

           Aexit(N) represents the state of the partial

accumulator sign bits, at the time of the last early exit

10   for a search region.

           For these blocks I + n, the SAD calculation is

terminated when the distortion exceeds that threshold.

This forms a causal system using previous information

that is known about the search region.

15   The usual system is based on the image

characteristics within a search region being some

probability of maintaining common characteristics from

time to time. The time between frames is between 1/15

and 1/30 of second, often fast enough that minimal

20   changes occur during those times above some noise floor

related to measurable system characteristics. Also,

there are often regions of an image which maintains

similar temporal characteristics over time.

According to the present application, the
accumulator unit for each SAD can be loaded with the
value (- least/n), where "least" represents the minimum
distortion that is measured in the block motion search
5   for the region. Many SAD's are calculated for each
search region. The first SAD calculating for the region
is assigned the "Least" designation. Future SADs are
compared to this, to see if a new "Least" value has been
established. When the accumulators change sign, the
10   minimum distortion has been reached. Moreover, this is
indicated using only the existing SAD structure, without
an additional calculation, and hence additional cycle(s)
for the test.

A test of the character of the image can be used to
15   determine how many of the accumulators need to switch
before establishing the early exit. For example, if
source and target regions are totally homogeneous, then
all the accumulators should change sign more or less at
the same time. When this happens, any one of the running
20   SAD calculations exceeding the previous least measurement
can be used to indicate that an early exit is in order.

This, however, assumes total image homogeneity.
Such an assumption does not always hold. In many
situations, the multiple accumulators of the different

10

SAD units will not be increasing at the same rate.

Moreover, the different rate of increase between the

accumulators may be related directly to the spatial

frequency characteristics of the differences themselves,

5   between the source and target block, and also to the

method of sampling the data. This can require more

complex ways of considering how to determine early exit,

based on what happens with the SAD units.

One operation is based on the probability associated

10   with a split SAD state; where not all of the SAD units

are in the same state. This difference in rate of

increase between the accumulators is related to the

spatial frequency characteristics of the difference

between the source and target block. Since these spatial

15   frequency characteristics are also correlated among

temporally similar frames, the information from one frame

may also be applied to analysis of following frames.

This is explained herein with reference to variables

– where A_1, A_2, A_3 ... A_n are defined as events associated

20   with a split SAD calculation.

The events can be defined as follows:

Event A_i = $SAD_i \geq 0$ where SAD < 0 for i ≠ j.

This conceptually means that the event A_i is defined

as occuring when SAD unit i is positive and all the

remaining SAD units are negative. This would occur, for

example, when the accumulators were increasing at

different rates. This can also be defined as combined

events, specifically:

5　　　　　Event $B_{i,j} = A_i \cup A_j = SAD_i \geq 0$ for $SAD_j \geq 0$, and

where $SAD_k < 0$ for $k \neq i$, j. This means that event

$B_{i,j}$ is defined as "true" when A_i exists and A_j are true,

but all other A_k are false. The concept of defining the

operations in terms of events can be extended to include

10　　all the possible combinations of i, j and k. This

yields, for 4 SAD units, a total of 16 combinations.

For larger numbers of SAD units, it leads to other

numbers of combinations, and possibly using more

variables, such as i, j, k and m or others.

15　　　　　Describing this scenario in words, each event "B" is

defined as the sum of the specified accumulators being

greater than 0. Each of these combinations is defined as

a probability. For 4 SAD units, there are total of 16

possible states of accumulators. These can be grouped

20　　according to how they are handled.

A first trivial possibility is

$P (B | \bar{A}_1 \cap \bar{A}_2 \cap \bar{A}_3 \cap \bar{A}_4) = 0$.

This means that the probability that sum of the accumulators is > 0, given that none of the accumulators has exceeded 0, is 0.

The opposite is also true:

5      $P(B|A_1 \cap A_2 \cap A_3 \cap A_4) = 1;$

Which means that the probability of the sum of all the accumulators is set, given that none of them are set, is also 1.

Excluding these trivial characteristics, there are

10   14 nontrivial combinations. The first group includes four cases where one of the accumulators is set and the remaining three are not set:

$P(B| A_1 \cup (\bar{A}_2 \cap \bar{A}_3 \cap \bar{A}_4),$

$P(B| A_2 \cup (\bar{A}_1 \cap \bar{A}_3 \cap \bar{A}_4),$

15   $P(B|A_3 \cup (\bar{A}_1 \cap \bar{A}_2 \cap \bar{A}_4),$

$P(B|A_4 \cup (\bar{A}_1 \cap \bar{A}_2 \cap \bar{A}_3).$

Another group represents those conditions where two of the accumulators are set, and the other two accumulators are not set. These combinations are written

20   as:

$$P(B|A_1 \cap A_2) \cup (\bar{A}_3 \cap \bar{A}_4)$$

$$P(B|A_1 \cap A_3) \cup (\bar{A}_2 \cap \bar{A}_4)$$

$$P(B|(A_1 \cap A_4) \cup (\bar{A}_2 \cap \bar{A}_3)$$

$$P(B|A_2 \cap A_3) \cup (\bar{A}_1 \cap \bar{A}_4)$$

5 $$P(B|A_2 \cap A_4) \cup (\bar{A}_1 \cap \bar{A}_3)$$

$$P(B|A_3 \cap A_4) \cup (\bar{A}_1 \cap \bar{A}_2)$$

Finally, the following group represents the cases

where three accumulators are set and one accumulator is

not set

10 $$P(B|A_1 \cap A_2 \cap A_3) \cup \bar{A}_4)$$

$$P(B|A_2 \cap A_3 \cap A_4) \cup \bar{A}_1)$$

$$P(B|A_1 \cap A_3 \cap A_4) \cup \bar{A}_2)$$

$$P(B|A_1 \cap A_2 \cap A_4) \cup \bar{A}_3).$$

The present embodiment recognizes that each of these

15 groups, and in fact each of these situations, represents

a different condition in the image. Each group or each

situation can be handled differently.

This system operates as above, and as described with

reference to the flowchart of Figure 5. The final goal

20 is to complete the calculation, and hence to exit,

sooner. This is shown in Fig 5 by first, determining

matching characteristics of two images; a source image

and a search image at 550. The matching characteristics

14

are calculated without any early exit. The minimum

distortion is found at 555 and the conditions when that

minimum distortion existed are found at 560.

The conditions at 560 can include a grouping type

5   that existed at the time of minimum distortion, or the

specific condition among the 14 possibilities.

At 570 a subsequent image part is tested. This

subsequent part can be any part that is correlated to the

test part. Since temporally correlated images are

10   assumed to be correlated, this can extend to any

temporally correlated part.

The image source and search are tested, and a

determination of the specific groupings that occurred at

the time of minimum distortion is found at 575. An early

15   exit is then established, at 580.

The early exit, once determined, can be carried out

in a number of different ways.

Figure 6a shows a system of carrying out the early

exit using an early exit or "EE" flag. N SAD units are

20   shown, where in this embodiment, N can be 4. Each SAD

unit includes the structure discussed above, and

specifically ALUs, inverters, and accumulators.

The output of each of the accumulators is coupled to

a combinatorial logic unit 600 which arranges the

outputs. This can be used to carry out the group

determination noted above. The combinatorial logic unit

is carried out using discrete logic gates, e.g., defined

in hardware definition language. The gates are

5　programmed with an option based on the selected group.

Different images and parts may be processed according to

different options.

For each option, the combination of states, e.g.,

the group discussed above, is coded. The combinatorial

10　logic monitors the accumulators of all the SAD units.

_　Each state is output to a multiplexer.

When those accumulators achieve a state that falls

within the selected coding, an early exit flag is

produced. The early exit flag means that the hardware

15　has determined an appropriate "fit". This causes the

operation to exit.

Figure 6B shows an alternative system, in which the

states of the accumulators are sensed by a hardware

status register 600. The status register is set to a

20　specified state by the condition of the accumulators.

The status register stores the specified condition that

represents the early exit. When that specified condition

is reached, the early exit is established.

The way in which the adaptive early exit is used,
overall, is described in reference to Figure 7. At 700,
the video frame starts. 705 represents buffering both
frame M and frame M+1. 710 is a determination if the
5   block history model needs update. This can be determined
by, for example, monitoring of the time since a previous
frame update. For example, x seconds can be established
as a time before a new update is necessary.

If the model needs updating, then the process
10   continues by loading the accumulators with 0xFF01 and
setting the local variable N=1 at 715. At 720, the
system obtains SAD search region N and uses the periodic
exit test $T_{exit} = 1/16...$, at step 725 the exit test is
performed. If successful, a local variable Kexit(N),
15   which is the pixels before exit and Aexit(N) which is an
summary of accumulators 1 through 4 before exit restored.
The local variable n is also incremented at step 730.
This establishes the local parameters, and the process
continues.

20   In a subsequent cycle the block history of update
does not need to be redone at step 710, and hence control
passes to step 735. At this step, the previously stored
Kexit and AEexit are read. This is used as the new count
at step 740 to set target block flags.

At step 745, a search for block N is established, an a exit and Kexit are updated at step 750. N is incremented. At step 755, a determination is made whether N is equal to 397. 397 is taken as the number of

5 frames in the buffer, since there are 396, 16x16 blocks in a 352x288 image. However, this would be adjusted for different size sizes as applicable.

Again, the temporal variations of large portions of an image are likely to remain unchanged. Therefore, when

10 the partial accumulators have a specific sign bit, their state produces significant advantages. Moreover, the time between frames is usually on the order of 1/15 to 1/30 of a second. Finally, regions within the image maintain their localized characteristics, and therefore

15 their spatial frequency may be correlated.

Although only a few embodiments have been disclosed, other modifications are possible.

20

What is claimed is:

1.   A method comprising:

        determining a minimum distortion between two

5   regions;

        loading a value related to said minimum

distortion into an accumulating element;

        accumulating results of subsequent image

distortion calculations into said accumulating

10   element; and

        establishing said minimum distortion for said

subsequent calculation exit when said accumulating

element reaches a predetermined value.

15 2.   A method as in claim 1, wherein there are a plurality

of said accumulating elements, and said loading

comprises loading said value into each of said

accumulating elements.

20 3.   A method as in claim 2 wherein said establishing

occurs when specified accumulating elements of said

plurality of accumulating elements reach said

predetermined value.

4.   A method as in claim 2 wherein said establishing

occurs when all of said plurality of accumulating

elements reach said predetermined value.

5   5.   A method as in claim 2 wherein said establishing

occurs when a single accumulating element reaches

said predetermined value.

6.   A method as in claim 2 wherein said value related to

10   said minimum distortion is an amount of distortion,

divided by a number of said accumulating elements.

7.   A method as in claim 2 further comprising determining

a character of the regions, and determining, from

15   said character, a number of accumulating elements to

require to reach said predetermined value before

said establishing.

8,   A method as in claim 7, wherein said character of the

20   image indicates a homogeneous image, and said

establishing said minimum distortion is based on

results from a single accumulator.

9. A method as in claim 7, wherein said establishing

comprises establishing said early exit based on

results from plural accumulators.

5 10. A method as in claim 9 wherein said early exit

comprises determining probabilities of each of the

accumulators establishing certain states, and said

establishing is based on said accumulators

establishing said certain states.

10

11. A method as in claim 6, wherein said predetermined

value is zero.

12. A method comprising:

15   determining a distortion between two image

regions; and

carrying out an early exit scheme without using

an extra calculation cycle for the early exit

scheme.

20

13. A method as in claim 12 wherein said early exit is

calculated by loading a value into an accumulator

element and changing said value based on said

determining.

14. A method as in claim 13, wherein there are a

     plurality of said accumulator elements, and said

     loading comprises loading said value into each of

5   said accumulator elements.

15. A method as in claim 14 wherein said establishing

     occurs when specified accumulator elements of said

     plurality of accumulator elements reach a

10   predetermined value.

16. A method as in claim 14 wherein said establishing

     occurs when all of said plurality of accumulator

     elements reach said predetermined value.

15

17. A method as in claim 12 wherein said value is

     related to a minimum distortion in a previous

     calculation.

20 18. A method as in claim 13 further comprising

     determining a character of the regions, and

     determining, from said character, a number of

     accumulator elements to require to reach said

     predetermined value before said establishing.

19.   A method as in claim 18, wherein said character of

the image indicates a homogeneous image, and said

establishing said minimum distortion is based on

5   results from a single accumulator element.

20.   A method as in claim 15, wherein said value is zero.

21.   A method of determining distortion between image

10   blocks comprising:

determining a first distortion between a first

image part and a second image part, and obtaining a

count of calculations for an early exit and state of

certain calculation at the time of the early exit;

15   and

in a subsequent calculation, terminating a

calculation based on both said count and said state.

22.   A method as in claim 21 wherein said distortion is

20   calculated by loading values into accumulators and

establishing an early exit when said accumulators

reach a specified value.

23.　A method as in claim 22, wherein said specified

value is zero.

24.　A method of processing image parts comprising;

5　　　　obtaining image distortion information about a

first image part; and

using said image distortion information to

process a second part, by loading a value related to

said image distortion information into a calculating

10　element, and terminating a calculation performed by

said calculating element when said value reaches a

predetermined amount.

25.　A method as in claim 24 wherein said image

15　distortion information includes a minimum of

distortion measured in a block motion search.

26.　A method as in claim 24 wherein said image

distortion is used to calculate a distortion in a

20　sum of absolute differences device with an

accumulator.

27.　A method as in claim 26 wherein said value is loaded

into the accumulator.

28. A method as in claim 18 wherein said value comprises

(-least/n) where least is a value found in a

previous cycle and n is a number of accumulators.

5

29. A method as in claim 28 wherein said predetermined

amount is 0.

30. A method as in claim 18 wherein said accumulators

10   are loaded with a said value (-least/ n) where least

is an expected early value and n is a number of

accumulators, and wherein an early exit is

established when an accumulator reaches 0.

15 31. A method as in claim 22 wherein said value

represents sign bits of the accumulators.

32. A method, comprising;

obtaining a plurality of image manipulating

20   devices which achieve specified states based on

relationships between two images;

accumulating results based on said

relationships, and

determining whether a calculation is completed

based on the states of the accumulating.

5   33.   A method as in claim 32, wherein said image

manipulating device is part of a video camera.

34.   An apparatus, comprising:

10   a calculating device, including an accumulator

element, that calculates values related to a minimum

distortion between two regions;

a buffer, storing a value related to said

minimum distortion, and loading said distortion into

15   said accumulator; and

a logic unit, establishing a minimum distortion

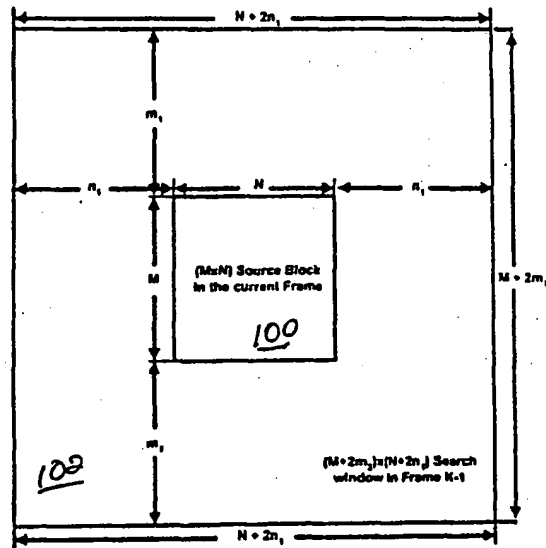based on a value in said accumulating device.

35.   An apparatus as in claim 34, wherein there are a

20   plurality of said calculating devices, and said

distortion is loaded into each of said accumulating

elements.

36. An apparatus, comprising:

a video acquiring device;

a plurality of calculating devices, each

including an accumulator element, that calculates

5   values related to a minimum distortion between two

video portions acquired by said video acquiring

device;

a buffer, storing a value related to said

minimum distortion, and loading said distortion into

10   said accumulators; and

a logic unit, establishing a minimum distortion

based on values in said accumulating device.

37. An apparatus as in claim 36 wherein said logic unit

15   monitors sign bits of said accumulator elements.

38. An apparatus as in claim 36 wherein said logic unit

monitors a value in said accumulator elements.

20 39. An apparatus as in claim 36, wherein said video

acquiring device is a video camera.

40. An apparatus as in claim 38, wherein said logic unit

monitors a value in all of said plurality of

accumulating elements to reach said predetermined

value.

41.   An apparatus as in claim 36, wherein said

5   accumulators are loaded with a value (-least/n)

where least is an expected early value and n is a

number of accumulators, and wherein an early exit is

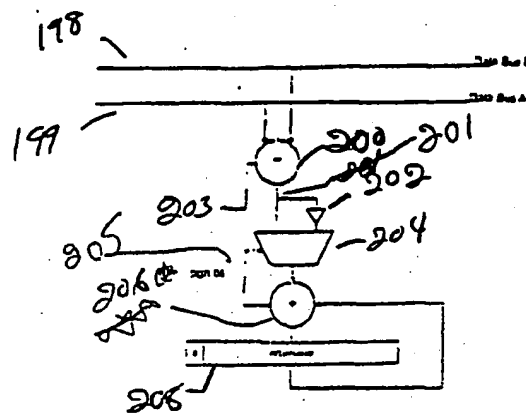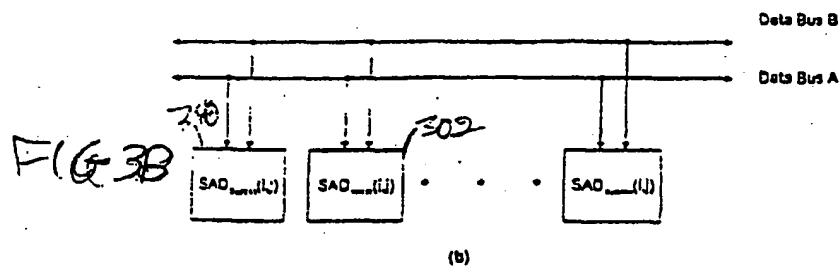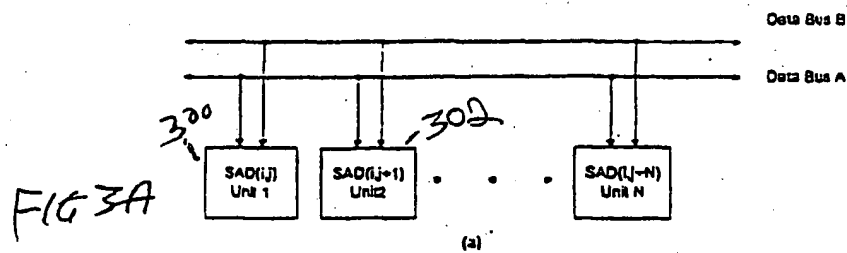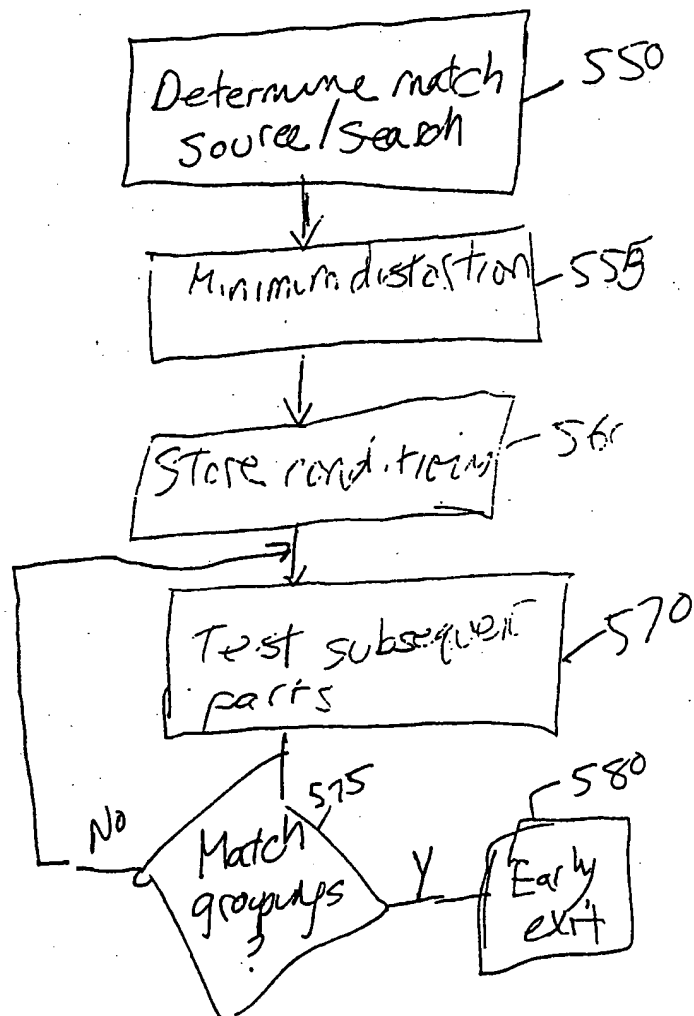established when an accumulator reaches 0.

FIG
1

FIG 2

FIG 3A
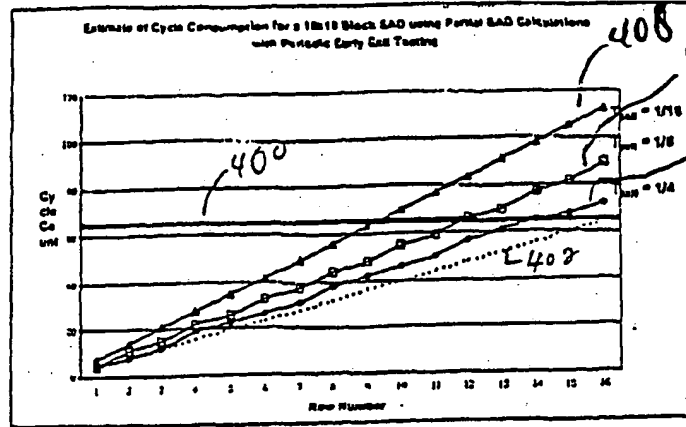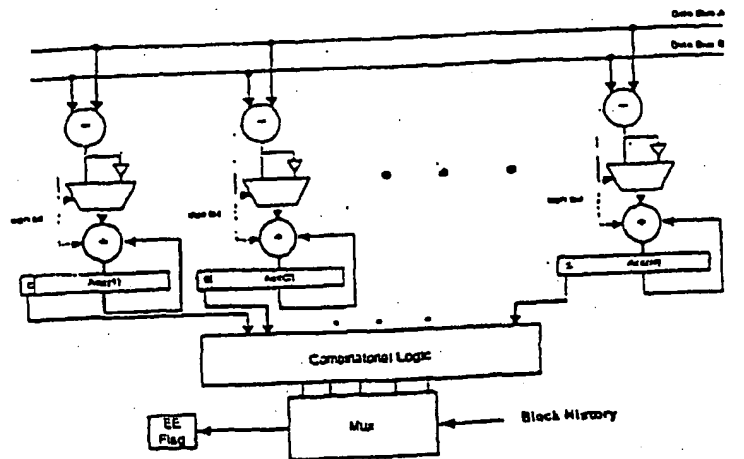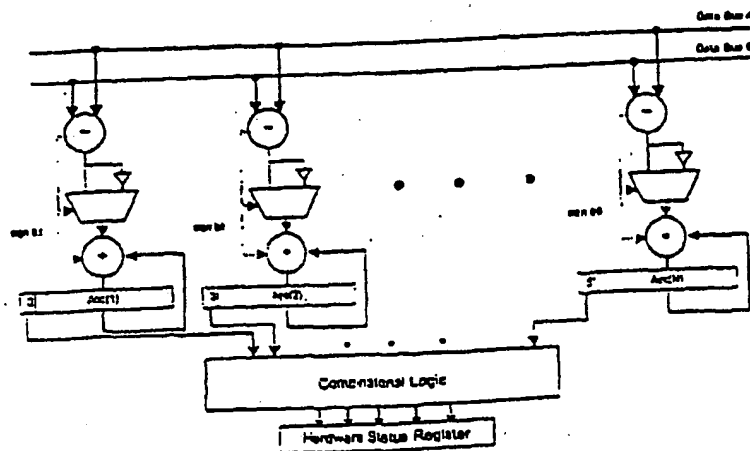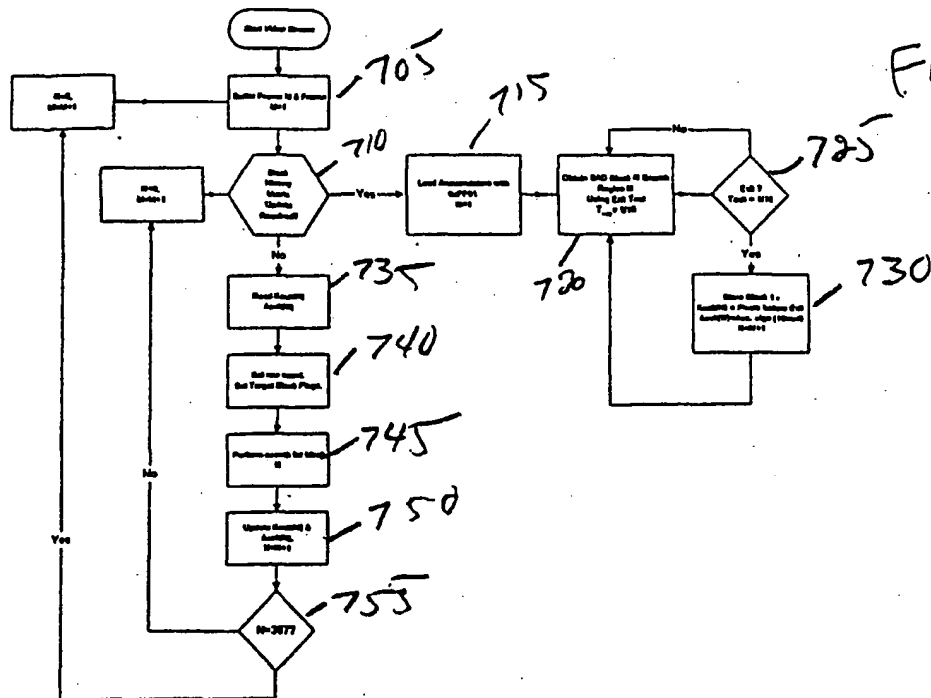
(a)

FIG 3B

(b)

Determine match Source/Search — 550

Minimum distortion — 555

Store conditioning — 560

Test subsequent parts — 570

Match groupings? — 575

No

Y

Early exit — 580

FIG 5

FIG 4

FIG 6A

FIG 6B

FIG 7

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/26 H04N7/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal, WPI Data

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[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

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Date of the actual completion of the international search 3 September 2001	Date of mailing of the international search report 12/09/2001

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